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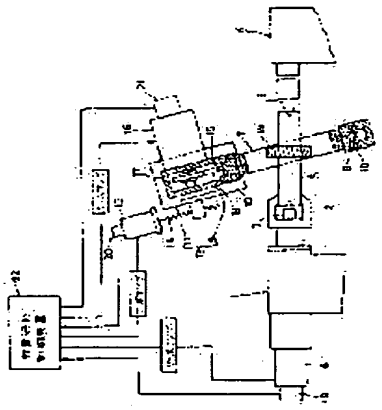
(54) FINISHING METHOD FOR GEAR

(57)Abstract:
PURPOSE: To eliminate fluctuation of machining accuracy and improve machining accuracy in stable state by correcting the position of a grinding wheel according to the backlash detected by a sensor in the meshing condition of a gear to be worked with the grinding wheel.
CONSTITUTION: When reference positions of a work W and a grinding wheel 7 are calculated, the reverse rotation command per one pulse is given to a main spindle motor 6 so as to intermittently reversely rotate the work W by a minute quantity. When following rotation of the grinding wheel 7 is begun, rotation of the work W is stopped, and rotating displacement during the time of the work W is counted as the number of pulse generated in a pulse generator 19. This rotating displacement corresponds to the backlash between the work W and the grinding wheel 7. Next, when the calculated value of backlash is obtained, a position correcting quantity of a grinding wheel table 12 necessary to make the backlash zero, namely a necessary approaching quantity of the grinding wheel 7 to the work W hereafter is searched, and the control system of a feed motor 13 is commanded to approach the grinding wheel 7 to the work W by the position correcting quantity to appropriately mesh with each other.



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TITLE OF THE INVENTION

A finishing method of gear

[Claims for the Patent]

(1)

In a finishing method for finishing a gear to be processed, which comprises the following steps:

a step that center impeller supports the gear which should be processed with head-stock comprising a spindle motor and tail stock,

a step which it is supported by a wheel-spindle stock, and rotationally drive a gear-shaped abrasive wheel by means of an abrasive wheel drive motor,

a step which gives a wheel-spindle stock feed by feed motor by it synchronizes by engaging a wheel-spindle stock with gear to be processed, and turning and,

the finishing method of gear characterized by the following processes:

a process which by quantity of turns intermittently minute in gear to be processed in the condition which engaged an abrasive wheel with gear to be processed before a work by a spindle motor,

a process calculating the reamer reference position which it is, and an abrasive wheel turns around with a revolution of gear to be processed, and begin to do,

a process making gear to be processed reverse by a minute amount from a reamer reference position by means of a spindle motor intermittently,

a process detecting revolution displacement magnitude of gear to be processed before it is again, and an abrasive wheel turns around from said reamer reference position, and beginning to do with a sensor,

a process which above revolution displacement magnitude is based on, and calculate position augmenter of the abrasive wheel that it is necessary to do gear to be processed and backlash between things of an abrasive wheel in a zero,

a process which gear to be processed and backlash between things of an abrasive wheel are based on above position augmenter so that it is in a zero, and feed is given a wheel-spindle stock by feed motor, and revise a position of an abrasive wheel.

DETAILED DESCRIPTION OF THE INVENTION

FIELD OF INDUSTRIAL APPLICATION:

The present invention relates to a finishing method of gear by grinding.

PRIOR ART:

Face roughness of spur gear and tooth flank of a hasu both teeth wheel and improvement of tooth form accuracy are aimed for, and that finishing of gear is put is conducted by grinding.

Finishing by such a grinding makes, for example, support center impeller with head-stock and tail stock in gear to be processed, it makes do an each synchronous rotation with an abrasive wheel drive motor with an abrasive wheel by a spindle motor in gear to be processed while this cover work gear and an abrasive wheel of form of internal gear can be engaged, what is ground using sliding contact between gear to be processed and tooth flank with an abrasive wheel by turning gear to be processed and abrasive wheel like gear set is done with a base.

A problem to be solved by the invention

In such a conventional finishing method, it is an ideal that gear to be processed and abrasive wheel can be engaged so that the backlash becomes a zero, and conduct a

work.

However, after having matched a phase with an abrasive wheel with gear to be processed, even if prescribed feed was given a wheel-spindle stock for the purpose of it being, and gear to be processed and center-distance with an abrasive wheel were able to engage both parties with prescribed value, a fighting each other condition of the both parties may not become always given.

This is so that a work error at the time of the cutting that individual gear has and an abrasion condition of an abrasive wheel delicately influence, and in this situation improvement of accuracy of finishing cannot be expected.

Because of this after it was unavoidable, and an operator brought gear to be processed and abrasive wheel close slowly, and, in the event of the gear which high accuracy was demanded from, having been able to engage both parties, normal and reverse rotations can put gear to be processed or an abrasive wheel, and a fighting each other condition of both parties is confirmed.

However, as for the activity, the place that is due to experience and perception is big, dispersion is easy to be produced by an individual operator to be able to ache, a problem is still had on a thing of equalization of gear cutting accuracy.

Further because gear to be processed and coming together activity itself with an abrasive wheel are hand work, when all automation of gear cutting is propelled, it is with big trouble.

The present invention was finished in view of problems such as the above.

gear to be processed and backlash between things of an abrasive wheel are grasped quantitatively, and there is for the purpose of the backlash providing the reasonable method that it is engaged, and was able to create a condition automatically how it is in a zero.

MEANS FOR SOLVING PROBLEM:

Including the process that the present invention is the following:

a step that center impeller supports gear to be processed with head-stock comprising a spindle motor and tail stock,

a step which it is supported by a wheel-spindle stock, and rotationally drive a gear-shaped abrasive wheel with an abrasive wheel drive motor,

a step which makes both parties is engaged by means of giving a wheel-spindle stock feed by feed motor, and do a synchronous rotation,

the finishing method of the gear which made finishing on gear to be processed,

the finishing method of gear characterized by means of the following processes:

a process which by quantity of turns intermittently minute in gear to be processed in the condition which engaged an abrasive wheel with gear to be processed before a work by a spindle motor,

a process which calculates the reamer reference position which it is, and an abrasive wheel turns around with a revolution of gear to be processed, and begin to do,

a process which makes gear to be processed reverse by a minute amount from a reamer reference position by a spindle motor intermittently,

a process which detects revolution displacement magnitude of gear to be processed before it is again, and an abrasive wheel turns around from the reamer reference position, and beginning to do with a sensor,

a process which the revolution displacement magnitude is based on, and calculate

position augmenter of the abrasive wheel that it is necessary to do gear to be processed and backlash between things of an abrasive wheel in a zero,

a gear to be processed and a backlash between things of an abrasive wheel become a zero, it is the step which the position augmenter is based on, and feed is given a wheel-spindle stock by feed motor, and revise a position of an abrasive wheel.

Operation

According to this method, gear to be processed and a real backlash between things of an abrasive wheel are detected, gear to be processed and a backlash between things of an abrasive wheel become a zero at a stage to begin finishing by this backlash is accepted, and revising a position of an abrasive wheel, and the fighting each other condition which is appropriateness according to an ideal is provided.

Example

FIG. 2 - FIG. 4 is an architecture explanatary drawing representing an example of the finishing device which the present invention is applied to.

When, as for cover work gear (for purposes of this example, it is shown to that example of a hasu both teeth wheel, a the following work-piece is feigned) W comprising shank S, is supported the one end in chuck 2 of head-stock 1 side and head center 3, and, as shown in FIG. 2, is supported other edge in tail center 5 of four tail stock sides, is rotationally driven by spindle motor 6.

Circumferentially internal gear engaging with this work-piece W-shaped abrasive wheel 7 of work-piece W, is arranged in form supported to abrasive wheel electrode holder 8, abrasive wheel electrode holder 8 goes through axle box baring 10 to housing 9 as shown in FIG. 3 and FIG. 4, and is supported rotatably.

Housing 9 is coupled to sliding base 11 by one body, and wheel-spindle stock 12 is comprised with sliding base 11.

And feed is given by feed motor 13 and ball screw 14, and, as for wheel-spindle stock 12, advance go-astern comes to work.

Chain 18 is about to be wound up between chain sprocket 15 of eight abrasive wheel electrode holder sides and chain sprocket 17 of 16 abrasive wheel drive motor sides while chain sprocket 15 is formed in circumference of abrasive wheel electrode holder 8 by one body, and abrasive wheel 7 goes through chain 18 with abrasive wheel drive motor 16, and it is rotationally driven.

Thus, after having engaged abrasive wheel 7 with work-piece W, because an each synchronous rotation can put abrasive wheel 7 with abrasive wheel drive motor 16 by spindle motor 6, work-piece W and abrasive wheel 7 do work-piece W like a relationship of gear set, and it rotates, grinding finishing is put for tooth flank of a work-piece W side for sliding contact between tooth flank of both parties.

In addition, spindle motor 6, feed motor 13 and abrasive wheel drive motor 16 has pulse generator 19.20 or 21 as a position sensor in each, each pulse generator 19,20.21 form a position feedback control loop between location control equipment 22.

Axle box baring electrode holder 23 is gone through as shown in FIG. 3 and FIG. 4 to a side of abrasive wheel electrode holder 8, and magnet 24 is assembled, magnetic sensor 25 actuating magnet 24 as a to be detected thing to the other, housing 9 goes through bracket 26, and is assembled.

When this magnetic sensor 25 faces magnet 24, when, using the property that magnetic field changes into in the case that is not so, abrasive wheel 7 is calculated

in prescribed constant angle stopping place with a thing outputting the magnetic field change as a change of current value, is used.

As thus described a step shown in a flow chart of FIG. 1 is depended on when a finishing device composed of is used, and a work is conducted.

Abrasive wheel 7 is turned with abrasive wheel drive motor 16 while work-piece W is turned by spindle motor 6, and a gear tooth of work-piece W calculates as shown in FIG. 1 and FIG. 2 for the purpose of it being in a prescribed phase, and a gear tooth of abrasive wheel 7 is calculated so that a phase of a gear tooth of a work-piece W side and a phase of a gear tooth of seven abrasive wheel sides agree.

As for this, a gear tooth of abrasive wheel 7 is calculated by stopping a revolution of abrasive wheel drive motor 16 in FIG. 3 and the position that magnetic sensor 25 faced magnet 24 as shown in FIG. 4.

If work-piece W and indexing of abrasive wheel 7 were completed, feed motor 13 is operated, and feed is given wheel-spindle stock 12, only specified quantity advances wheel-spindle stock 12 by quick traverse.

The stroke that should advance wheel-spindle stock 12 is set beforehand, because, besides, a phase with abrasive wheel 7 has already agreed with work-piece W as discussed above, work-piece W and abrasive wheel 7 will be engaged in a rough condition hereby.

A revolution command every one pulse is given as against spindle motor 6 successively, and by pettiness amount turns work-piece W intermittently, till abrasive wheel 7 begins to rotate by this action, it is continued.

In other words, Till, at the same time, it is, and abrasive wheel 7 turns around, and it begins to be done for a revolution of work-piece W, work-piece W is turned intermittently, a revolution of work-piece W is stopped in the point that abrasive wheel 7 is, and it turns around, and have begun to be done.

Here, Because magnetic sensor 25 detects this promptly when little, magnet 24 facing magnetic sensor 25 beforehand moves, it can confirm whether it is, and abrasive wheel 7 turns around, and it has begun to be done.

The condition which work-piece W and one tooth flank Fa of abrasive wheel 7, Fb touched to represent to FIG. 5 is created by the above, this position becomes a reamer reference position.

If a reamer reference position was calculated, it makes a reverse rotation command every one pulse is given as against spindle motor 6 this time, and work-piece W reverse by a pettiness amount intermittently.

And, Till, at the same time, it is, and abrasive wheel 7 turns around, and it begins to be done in reverse rotation of work-piece W, it makes work-piece W reverse, pulse generator 19 of six spindle motor sides counts revolution displacement magnitude of work-piece W in the meantime as occurring pulse number P while a revolution of work-piece W is stopped in the point that abrasive wheel 7 is, and it turns around, and have begun to be done.

This revolution displacement magnitude is equivalent to work-piece W and backlash amount $\triangle$ C (FIG. 5) between things of abrasive wheel 7.

In addition, It is detected whether it is, and abrasive wheel 7 turns around, and it has begun to be done with magnetic sensor 25 same as the above.

If revolution displacement magnitude of work-piece W was provided as pulse number P1, backlash amount $\triangle$ C is calculated by the next formula.

Total indexing pulse number, Dp when a one revolution was able to place work-piece W are work-piece pitch diameter, and, AC =(ff DP/PC) XPI here, Pc is both known value.

As discussed above, If value of backlash amount △ C was found, grinding this backlash amount △ C in a zero is demanded whether only which more should bring abrasive wheel 7 close to work-piece W in necessary position augmenter △ Z of wheel-spindle stock 12 namely a condition of FIG. 5 from by the next formula.

It is lan alpha to eight △ Z C In addition, Alpha is known value in pressure angle. Further, The a series of operations are conducted in arithmetic processing part in locating control equipment 22.

If position augmenter △ Z of wheel-spindle stock 12 was pursued, this position augmenter △ Z is applied to a control system of feed motor 13, and position augmenter AZ cook abrasive wheel 7, and further work-piece W can be approached.

By this, Work-piece W and backlash △ C between things of abrasive wheel 7 become a zero, it is engaged, and a backlash is in a reasonable condition with work-piece W and abrasive wheel 7.

It is awarded a work trigger command from locating control equipment 22 after this, and spindle motor 6 and abrasive wheel drive motor 16 actuates, work-piece W and abrasive wheel 7 seem to be gear set, and finishing by grinding is put for iko in what a synchronous rotation does same as before.

After it, finishing by grinding is put by abrasive wheel 7 totally synchronizes with work-piece W like gear set same as before, and rotating.

In addition, It is not necessary for compulsion to always turn work-piece W with spindle motor 6 in the case of grinding.

EFFECT OF THE INVENTION:

According to the present invention, normal and reverse rotations can put to be processed gear by a spindle motor in the condition which was able to engage an abrasive wheel with to be processed gear before work start-off as above.

After having detected a backlash at that time with a sensor, it is composed of to revise a position of an abrasive wheel depending on the backlash amount.

Therefore backlash amount can be grasped quantitatively in comparison with before.

Even in the case of the gear which a high accuracy is demanded from, dispersion of accuracy of finishing is lost thereby,

And it is matched with improvement of accuracy of finishing itself, and stabilization of accuracy of finishing can be planned.

Further while it participates, it will not be necessary an operator, and, by means of that backlash amount can be grasped quantitatively as above, maintaining accuracy of finishing of gear for identification of backlash amount, complete automation of gear cutting can be realized.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a flow chart representing one embodiment of the invention, and FIG. 2 is an architecture explanatary drawing representing an example of the finishing device which the present invention is applied to, and FIG. 3 is enlarged sectional view of a wheel-spindle stock of FIG. 2, and FIG. 4 is a right side surface explanatary drawing of FIG. 3, and FIG. 5 is the gear to be processed and explanatary drawing which it is engaged, and represent a condition with an abrasive wheel.

1.. head-stock,
3... head center,
4... tail stock,
5... tailing in flotation center,
6... spindle motors,
7.. abrasive wheels,
12... wheel-spindle stocks,
13... feed motor,
16... abrasive wheel drive motors,
19.. pulse generators (a sensor),
25... magnetic sensor,
W ... cover work gear,
A bC ... bank rush.

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審査請求　未請求　請求項の数 1　(全7頁)

⑤4発明の名称　歯車の仕上加工方法

⑳特　願　平2−325072
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明　細　書

1．発明の名称

歯車の仕上加工方法

2．特許請求の範囲

(1)主軸モータを備えたヘッドストックとテールストックとで両持ち支持される被加工歯車と、砥石台に支持されて砥石駆動モータにより回転駆動される歯車状の砥石とを、送りモータにより砥石台に送りを与えることで噛み合わせた上で両者を同期回転させることにより被加工歯車に仕上加工を施すようにした歯車の仕上加工方法において、

加工に先立って、被加工歯車と砥石とを噛み合わせた状態で主軸モータにより被加工歯車を微小量ずつ間欠的に回転させて、被加工歯車の回転に伴って砥石が連れ回りし始める基準位置を割り出す一方、主軸モータにより被加工歯車を基準位置から微小量ずつ間欠的に逆転させて、前記基準位置から砥石が再び連れ回りし始めるまでの被加工歯車の回転変位量をセンサにより検出する工程と、

被加工歯車と砥石との間のバックラッシュを零にするのに必要な砥石の位置補正量を前記回転変位量に基づいて算出する工程と、

被加工歯車と砥石との間のバックラッシュが零になるように、前記位置補正量に基づいて送りモータにより砥石台に送りを与えて砥石の位置を補正する工程、

とを含むことを特徴とする歯車の仕上加工方法。

3．発明の詳細な説明

産業上の利用分野

本発明は研削による歯車の仕上加工方法に関する。

従来の技術

平歯車やはす歯歯車の歯面の面粗度および歯形精度の向上を目的として、研削により歯車の仕上加工を施すことが行われる。このような研削による仕上加工は、例えば被加工歯車をヘッドストックとテールストックとで両持ち支持させ、この被加工歯車と内歯車状の砥石とを噛み合わせる一方、被加工歯車を主軸モータにより、砥石を砥石駆動モータによりそれぞれ同期回転させ、被加工歯車

と砥石とをあたかも歯車対のように回転させることによって、被加工歯車と砥石との歯面同士のすべり接触を利用して研削することを基本とする。

発明が解決しようとする課題

このような従来の仕上加工方法においては、被加工歯車と砥石とをそのバックラッシュが零になるように噛み合わせて加工を行うのが理想であるが、被加工歯車と砥石との位相を合わせた上で、被加工歯車と砥石との中心間距離が所定の値となるように砥石台に所定の送りを与えて両者を噛み合わせたとしてもその両者の噛み合い状態が常に一定になるとはかぎらない。

これは、個々の歯車がもつ機械加工時の加工誤差や砥石の摩耗状態が微妙に影響してくるためで、このままでは加工精度の向上が望めない。

このようなことから、高精度が要求される歯車の場合には、やむを得ず作業者が被加工歯車と砥石とを徐々に近付けて両者を噛み合わせた上で、被加工歯車もしくは砥石を正逆転させて両者の噛み合い状態を確認するようにしている。

しかしながら、上記の作業は経験と勘に負うところが大きいために個々の作業者によってばらつきが生じやすく、歯車加工精度の均一化の上でなおも問題を残している。また、被加工歯車と砥石との噛み合わせ作業そのものが手作業であるために歯車加工の全自動化を推進する上で大きな障害となっている。

本発明は以上のような問題点に鑑みてなされたもので、その目的とするところは、被加工歯車と砥石との間のバックラッシュを定量的に把握して、そのバックラッシュが零になるような適正な噛み合い状態を自動的につくり出すことができるようにした方法を提供することにある。

課題を解決するための手段

本発明は、主軸モータを備えたヘッドストックとテールストックとで両持ち支持される被加工歯車と、砥石台に支持されて砥石駆動モータにより回転駆動される歯車状の砥石とを、送りモータにより砥石台に送りを与えることで噛み合わせた上で両者を同期回転させることにより被加工歯車に仕上加工を施すようにした歯車の仕上加工方法において、加工に先立って被加工歯車と砥石とを噛み合わせた状態で主軸モータにより被加工歯車を微小量ずつ間欠的に回転させて、被加工歯車の回転に伴って砥石が連れ回りし始める基準位置を割り出す一方、主軸モータにより被加工歯車を基準位置から微小量ずつ間欠的に逆転させて、前記基準位置から砥石が再び連れ回りし始めるまでの被加工歯車の回転変位量をセンサにより検出する工程と、被加工歯車と砥石との間のバックラッシュを零にするのに必要な砥石の位置補正量を前記回転変位量に基づいて算出する工程と、被加工歯車と砥石との間のバックラッシュが零になるように、前記位置補正量に基づいて送りモータにより砥石台に送りを与えて砥石の位置を補正する工程とを含んでいる。

作用

この方法によると、被加工歯車と砥石との間の実際のバックラッシュを検出した上で、このバックラッシュに応じて砥石の位置を補正することにより、仕上加工を開始する段階では被加工歯車と砥石との間のバックラッシュが零となって理想どおりの適正な噛み合い状態が得られる。

実施例

第２図～第４図は本発明が適用される仕上加工装置の一例を示す構成説明図である。

第２図に示すように、軸部Ｓを備えた被加工歯車（この実施例ではははす歯歯車の例を示しており、以下ワークと称する）Ｗは、その一端をヘッドストック１側のチャック２とヘッドセンタ３とで支持されるとともに他端をテールストック４側のテールセンタ５で支持された上で主軸モータ６によって回転駆動される。

ワークＷの外周には、このワークＷと噛み合う内歯車状の砥石７が砥石ホルダ８に支持されるかたちで配設されており、砥石ホルダ８は第３図および第４図に示すようにハウジング９にベアリング１０を介して回転可能に支持されている。ハウジング９はスライドベース１１に一体に結合されていて、スライドベース１１とともに砥石台１２

を構成している。そして、砥石台１２は送りモータ１３とボールねじ１４とにより送りが与えられて前進後退動作するようになっている。

砥石ホルダ８の外周にはチェーンスプロケット１５が一体に形成されている一方、砥石ホルダ８側のチェーンスプロケット１５と砥石駆動モータ１６側のチェーンスプロケット１７との間にはチェーン１８が巻き掛けられていて、砥石７は砥石駆動モータ１６によりチェーン１８を介して回転駆動される。

したがって、ワークＷと砥石７とを噛み合わせた上で、ワークＷを主軸モータ６により、砥石７を砥石駆動モータ１６によりそれぞれ同期回転させることによって、ワークＷと砥石７とがあたかも歯車対の関係のようにして回転し、両者の歯面同士のすべり接触のためにワークＷ側の歯面に研削仕上加工が施される。

なお、主軸モータ６、送りモータ１３および砥石駆動モータ１６はそれぞれに位置検出器としてパルスジェネレータ１９，２０または２１を有しており、各パルスジェネレータ１９，２０，２１は位置決め制御装置２２との間で位置フィードバックループを形成している。

砥石ホルダ８の側面には第３図および第４図に示すようにベアリングホルダ２３を介して磁石２４が取り付けられており、他方、ハウジング９には磁石２４を被検出物として作動する磁気センサ２５がブラケット２６を介して取り付けられている。この磁気センサ２５は、磁石２４と正対している場合とそうでない場合とで磁界が変化する性質を利用して、その磁界変化を電流値の変化として出力するもので、砥石７を所定の定角停止位置に割り出す際に使用される。

このように構成された仕上加工装置を用いて加工を行う際には、第１図のフローチャートに示す手順による。

第１図および第２図に示すように、主軸モータ６によりワークＷを回転させてワークＷの歯が所定の位相となるように割り出す一方、砥石駆動モータ１６により砥石７を回転させて、ワークＷ側の歯の位相と砥石７側の歯の位相とが一致するように砥石７の歯を割り出す。これは、第３図および第４図に示すように磁気センサ２５が磁石２４と正対した位置で砥石駆動モータ１６の回転を停止させることにより砥石７の歯が割り出される。

ワークＷおよび砥石７の割り出しが完了したならば、送りモータ１３を作動させて砥石台１２に送りを与え、砥石台１２を早送りにて所定量だけ前進させる。砥石台１２を前進させるべきストロークは予め設定されており、しかも上記のようにワークＷと砥石７との位相が既に一致していることから、これによってワークＷと砥石７とがラフな状態で噛み合うことになる。

続いて、主軸モータ６に対して１パルスごとの回転指令を与えてワークＷを微小量ずつ間欠的に回転させ、この動作を砥石７が回転し始めるまで続ける。つまり、ワークＷの回転に併せて砥石７が連れ回りし始めるまでワークＷを間欠的に回転させ、砥石７が連れ回りし始めた時点でワークＷの回転を停止させる。

ここで、砥石７が連れ回りし始めたかどうかは、予め磁気センサ２５と正対している磁石２４が少しでも動くとこれを直ちに磁気センサ２５が検知することで確認できる。

以上により、第５図にも示すようにワークＷと砥石７の一方の歯面Ｆａ，Ｆｂ同士が接触した状態がつくり出され、この位置が基準位置となる。

基準位置が割り出されたならば、今度は主軸モータ６に対して１パルスごとの逆転指令を与えてワークＷを微小量ずつ間欠的に逆転させる。そして、ワークＷの逆転に併せて砥石７が連れ回りし始めるまでワークＷを逆転させ、砥石７が連れ回りし始めた時点でワークＷの回転を停止させる一方、その間のワークＷの回転変位量を、主軸モータ６側のパルスジェネレータ１９が発生するパルス数Ｐ，としてカウントする。この回転変位量はワークＷと砥石７との間のバックラッシュ量ΔＣ（第５図）に相当するものである。

なお、砥石７が連れ回りし始めたかどうかは上記と同様に磁気センサ２５で検知される。

ワークWの回転変位量がパルス数P_1として得られたならば、次式によりバックラッシュ量ΔCを算出する。

$$\Delta C = (\pi \cdot D_p / P_c) \times P_1$$

ここで、P_cはワークWを1回転させたときの総割り出しパルス数、D_pはワークピッチ円直径で、いずれも既知の値である。

上記のようにバックラッシュ量ΔCの値が求められたならば、このバックラッシュ量ΔCを零にするのに必要な砥石台12の位置補正量ΔZ、すなわち第5図の状態においてあとどれだけ砥石7をワークWに近付ければよいかを次式によって求める。

$$\Delta Z = \Delta C / \tan\alpha$$

なお、αは圧力角で、既知の値である。また、上記の一連の演算は位置決め制御装置22内の演算処理部で行われる。

砥石台12の位置補正量ΔZが求められたならば、この位置補正量ΔZを送りモータ13の制御系に付与して、砥石7を位置補正量ΔZだけさらにワークWに近付ける。これにより、ワークWと砥石7との間のバックラッシュΔCが零となり、ワークWと砥石7とはバックラッシュのない適正な噛み合い状態となる。

こののち、位置決め制御装置22からの加工開始指令を受けて主軸モータ6および砥石駆動モータ16が作動し、以降は従来と同様にワークWと砥石7とがあたかも歯車対のように同期回転することで研削による仕上加工が施される。

なお、研削の際には必ずしもワークWを主軸モータ6で強制回転させる必要はない。

発明の効果

以上のように本発明によれば、加工開始に先立ち、被加工歯車と砥石とを噛み合わせた状態で被加工歯車を主軸モータにより正逆転させ、そのときのバックラッシュをセンサにより検出した上でそのバックラッシュ量に応じて砥石の位置を補正するようにしているので、従来と比べてバックラッシュ量を定量的に把握することができ、それによって高精度が要求される歯車の場合でも、加工精度のばらつきをなくして加工精度そのものの向上と併せて加工精度の安定化を図ることができる。

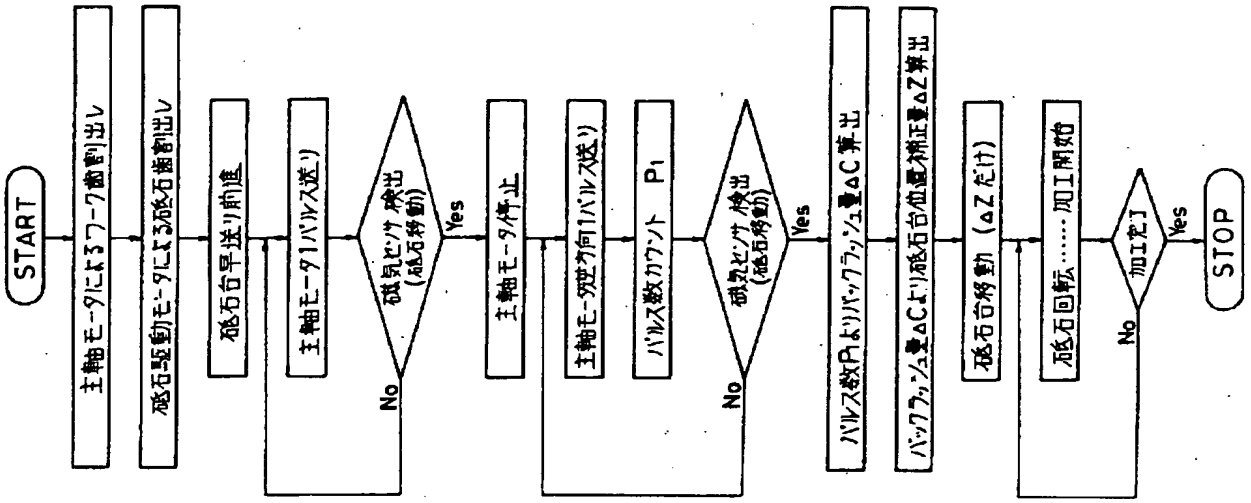
また、上記のようにバックラッシュ量を定量的に把握できることによってバックラッシュ量の確認のために作業者が関与する必要がなく、歯車の加工精度を維持しつつ歯車加工の完全自動化を実現できる。

4．図面の簡単な説明

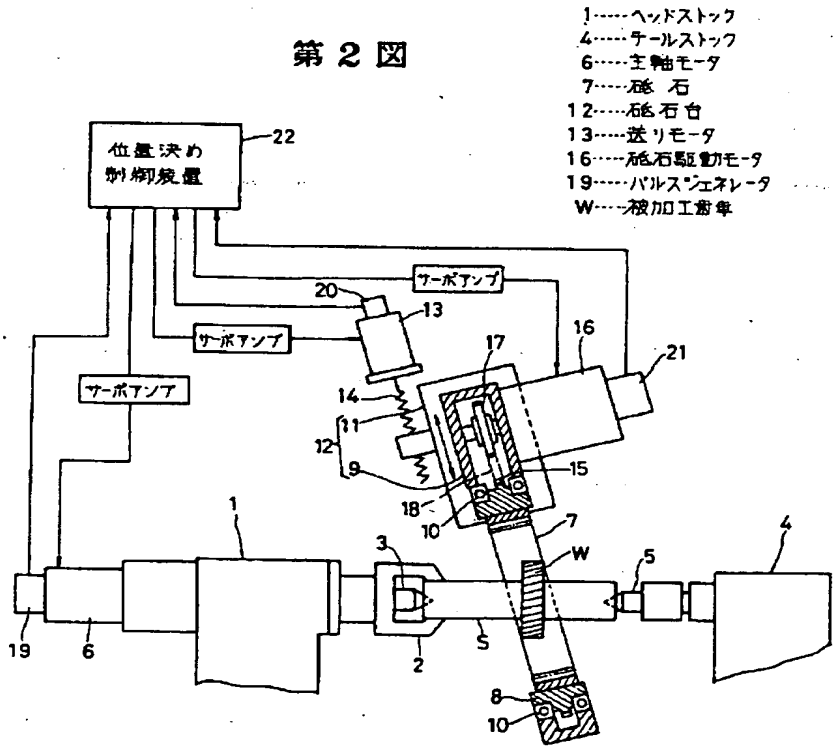
第1図は本発明の一実施例を示すフローチャート、第2図は本発明が適用される仕上加工装置の一例を示す構成説明図、第3図は第2図の砥石台の拡大断面図、第4図は第3図の右側面説明図、第5図は被加工歯車と砥石との噛み合い状態を示す説明図である。

1…ヘッドストック、3…ヘッドセンタ、4…テールストック、5…テールセンタ、6…主軸モータ、7…砥石、12…砥石台、13…送りモータ、16…砥石駆動モータ、19…パルスジェネレータ（センサ）、25…磁気センサ、W…被加工歯車、ΔC…バックラッシュ。

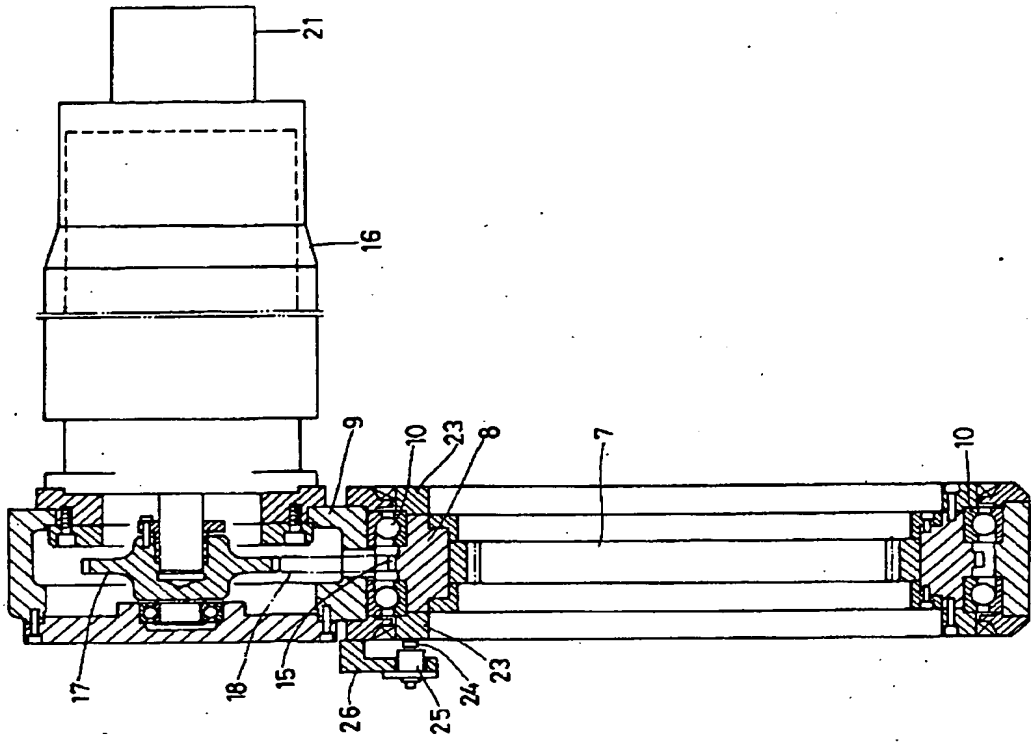
第1図


START
主軸モータによるワーク歯割出し
砥石駆動モータによる砥石歯割出し
砥石台早送り前進
主軸モータ1パルス送り
磁気センサ検出(砥石移動)
No
Yes
主軸モータ停止
主軸モータ逆方向1パルス送り
パルス数カウント P1
磁気センサ検出(砥石移動)
No
Yes
パルス数P1よりバックラッシュ量ΔC算出
バックラッシュ量ΔCより砥石台位置補正量ΔZ算出
砥石台移動 (ΔZだけ)
砥石回転……加工開始
加工終了
No
Yes
STOP

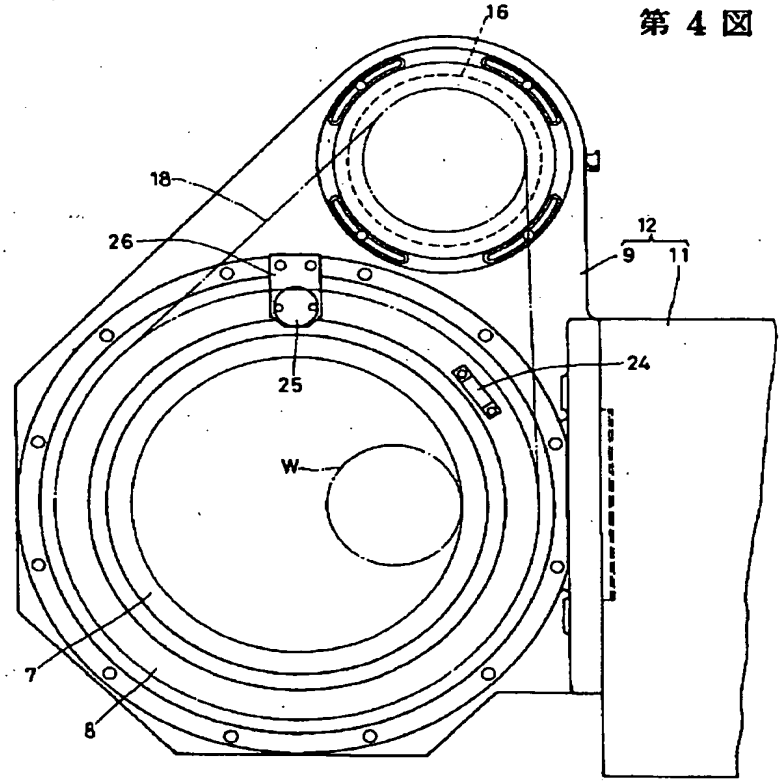
第2図


1……ヘッドストック
4……テールストック
6……主軸モータ
7……砥石
12……砥石台
13……送りモータ
16……砥石駆動モータ
19……パルスジェネレータ
W……被加工歯車
位置決め制御装置
22
サーボアンプ
サーボアンプ
サーボアンプ
20
13
16
17
21
14
11
12
9
15
18
10
7
W
3
5
4
1
19
6
2
5
8
10

第3図



第4図



第５図